APPENDIX D

CAUSAL ANALYSIS

D1.0 INTRODUCTION

A causal analysis was performed by the Fluor Daniel Hanford, Inc.(FDH) Radiation Protection Department and Project Hanford Management Contract (PHMC) contractor personnel to determine the root, direct, and contributing causes for the 200 East Area contamination event and determine judgments of need to prevent the conditions leading to each cause.

The event was the spread of radioactive contamination outside of a posted radiological area in the 200 East Area. The spread resulted in identification of contamination in uncontrolled areas of the Hanford Site and minimal offsite contamination including contamination identified in the City landfill. The root cause of the event was inadequate processes to prevent contamination via biological vectors (fruit flies) from spreading contamination outside of radiological areas (contamination areas). The direct cause of the event was the flying insects (fruit flies) that spread contamination from the 241-ER-152 Diversion Pit to controlled and uncontrolled areas in or near the 200 East Area. Fruit flies had never before been identified as a contamination spread vector in the U.S. Department of Energy complex Several contributing causes, including the application of a glycerin/monosaccharide (simple sugar)-based contamination, and the site processes and surveillance are explained.

This appendix explains the event root-cause analysis and the process used to determine the root cause, the direct cause, and the contributing causes of the incident. It identifies the causes and discusses the factors considered in determining the causes:

- Operations in the 241-ER-152 Diversion Pit
- Use of simple sugar-based contamination fixatives
- Vectors and transport pathways for the contamination spread
- Pick-up and delivery of refuse to the landfill
- Use of an offsite landfill.

Sections D.4 through D.6 describe the findings of the analysis and provide suggested remedial actions that can be taken to prevent another similar event.

D2.0 DEFINITIONS

Event. A real-time occurrence (e.g., pipe break, valve failure, spread of radioactive contamination).

Root Cause. The cause that, if corrected, would prevent recurrence of this and similar occurrences. The root cause does not apply to this occurrence only, but has generic implications to a broad group of possible occurrences.

Direct Cause. The cause that directly resulted in the occurrence.

Contributing Cause. A cause that contributed to an occurrence but, by itself, would not have caused the occurrence.

D3.0 DISCUSSION

On the Hanford Site, radioactive material that is present in the facilities, tanks, process equipment, underground waste sites, and contaminated surfaces is contained in posted radiological areas. These posted radiological areas are located within areas of the Hanford Site that are further controlled for radiological purposes. It is the PHMC policy that all personnel, equipment, and material that leaves any posted radiological area containing contamination or airborne radioactivity areas is surveyed for radiological contamination, to the limits that allow uncontrolled release to anywhere on or off the Hanford Site. Barriers, work processes, and surveillance, both routine and event generated, implement the PHMC policy that there will be no contamination spread outside of posted radiological areas.

On September 28, 1998, surface contamination was identified in and outside of an office/change trailer (the MO-967 Mobile Office) in the area immediately south of the B Plant/WESF facility. The finding of contamination outside of a posted radiological area initiated vigorous investigations, surveys, and mitigation actions. In the next days and weeks, contamination was identified primarily in the area south of B Plant/WESF, but also in some locations outside the controlled areas of the Site. In addition, minimal amounts of contamination were identified offsite in the City landfill and on socks in the home of a Site ironworker.

This causal analysis report compiles investigations and analyses of the FDH Radiation Protection Department into the contamination spread event. Included are the results and conclusions from a team of FDH and PHMC contractor personnel, activated during the event, that analyzed and reported on the radiological contamination data that had been collected in and around the affected areas. This team analyzed the likely vectors for the spread of the contamination and the potential sources of the contamination. In addition, this report includes results of an investigative committee of FDH and PHMC contractor personnel that was focused on the events and processes that led to the contamination of the City of Richland Landfill. This committee used the REASON™ event process model, software developed by Decisions Systems, Inc., to assist in explaining why and how the landfill contamination occurred.

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D3.1 OPERATIONS IN THE 241-ER-152 DIVERSION PIT

The work at the 241-ER-152 Diversion Pit on September 15, 1998, consisted of opening the pit and disconnecting flexible jumpers. The pit had been sprayed with fixative on September 10, 1998, in preparation for this work. The fixative application during this work activity was performed with a sprayer that was not long enough to reach the bottom of the pit. This contributed to the contamination spread during the work activity and may have compounded the amount of contamination spread by the fruit flies. A large amount of water was introduced into the pit during the work activity; this rinsed away some of the fixative and contributed to the localized spread of contamination. This is relevant to the fruit fly scenario only because water can serve as an attractant to fruit flies. This was not the only source of water in the area.

A contamination spread occurred during jumper work and was investigated as a potential cause of the contamination spread to the City landfill. This contamination spread associated with the work activity was determined not to be a factor in the spread of contamination to offsite locations. During the preparation and work process, fruit flies may have been attracted to or were isolated in the pit, where they were able to breed in the residual water and fixative in the pit. These contaminated fruit flies have been identified as a major contributor to contaminated refuse later transported to the City landfill. Some discussion centered on the application of fixative during the work activity and the presence of large quantities of water.

D3.2 USE OF GLYCERIN/MONOSACCHARIDE (SIMPLE SUGAR)-BASED FIXATIVE

A contamination fixative was used in the 241-ER-152 Diversion Pit on September 10, 1998. A good radiological practice is to use fixatives to help keep contamination from becoming airborne when work disturbs surfaces. This particular fixative was obtained from a contractor and consisted of a monosaccharide and glycerin in a water solution. The contractor either applies this fixative for clients as a fog, using an ultrasonic aerosol generator, or sells the solution directly to companies for their own application. This thin coating fixes radiation only temporarily because it washes away easily. This material has been used at the Hanford Site for the past 2 years without any problems (Table D-1). During this application, however, the material attracted or, at least provided a food source for, fruit flies. There is no indication that the manufacturer or anyone using this fixative at the Hanford Site performed a formal study of the potential of the material to attract or support biota. The levels of contamination in the 241-ER-152 Diversion Pit were sufficient to result in the contamination subsequently found on the fruit flies.

The fixative is sold by the manufacturer with an expiration date. Controls are in place to prevent the fixative from being issued in its original container after the expiration date, but no controls are in place to prevent its use once the fixative is issued or transferred to secondary containers. In the field, the fixative is stored in its original containers and sprayers, without any controls. This includes being stored in outside temperatures during the hot summer that immediately preceded this event. Sprayers are not cleaned between uses. Fixative in a sealed bottle has been reported to build up gas pressure after prolonged storage. When this gas is released, an odor similar to rotting fruit occasionally has been noted. This odor could enhance the attractiveness of the fixative to fruit flies.

Table D1. Selected Examples of the History and Use of Glycerin/Monosaccharide (Simple Sugar)-Based Fixatives at the Hanford Site.

Company	Date of Fixative Use	Facility Structure ID #	Sub-ID #	Fixative Applier	Fixative Type	Application Method	References (e.g., Technical Work Document #)	Comments
LMHC	Unknown	244-A						10/96? 1st use at 244-A, per LMHC
LMHC	Unknown	244-A						Per LMHC list
LMHC	Unknown	244-A						Per LMHC list
LMHC	Unknown	244-A						Per LMHC list
LMHC	03/01/97	244-A						Per LMHC list
LMHC	03/01/97	241-A	A-A pit					Per LMHC list
LMHC	04/01/97	241-A	A-A pit					Per LMHC list
BWHC	12/01/97	Tk-100	Vault	Vendor	Sugar	PAG	WESF work package #2B-97-01258/w	Per Vendor; confirmed by WESF
LMHC	02/01/98	241-AN	AN-B pit					Per LMHC list
LMHC	02/01/98	241-AW	02E pit					Per LMHC list
LMHC	02/01/98	241-A	A-A pit					Per LMHC list
LMHC	03/01/98	241-AN	AN-A pit					Per LMHC list
LMHC	03/01/98	241-A	A-A pit					Per LMHC list
LMHC	05/01/98	241-A	A-A pit					Per LMHC list
LMHC	06/01/98	241-ER	ER-153					Per LMHC list
LMHC	06/01/98	241-AW	02E pit					Per LMHC list
LMHC	06/01/98	241-A	A-A pit					Per LMHC list
LMHC	07/01/98	241-AY	02A pit					Per LMHC list
LMHC	07/01/98	241-AY	02D pit					Per LMHC list
LMHC	07/01/98	241-A	A-A pit					Per LMHC list
LMHC	08/01/98	241-A	A-A pit					Per LMHC list
LMHC	09/01/98	241-ER	ER-152	LMHC				Per LMHC list
LMHC	Unknown	244-A	Pit	Vendor	Sugar	PAG		Per Vendor list
LMHC	Unknown	244-A	filter pit	Vendor	Sugar	PAG		Per Vendor list
LMHC	Unknown	241-AY	102-A process pit	Vendor	Sugar	PAG		Per Vendor list
LMHC	Mar-98	241-AN	AN-A valve pit	Vendor	Sugar	PAG		Per Vendor list
LMHC	Feb-98	241-AN	AN-B valve pit	Vendor	Sugar	PAG		Per Vendor list
	Unknown	233-S	pipe trench	Vendor	Sugar	PAG		Per Vendor list
LMHC	Unknown	244-TX	DCRT pit	Vendor	Sugar	PAG		Per Vendor list

BWHC = B&W Hanford Company.
DCRT = double-contained receiver tank.
LMHC = Lockheed Martin Hanford Corporation.
PAG = passive aerosol generator.
WESF = Waste Encapsulation and Storage Facility.

D3.3 VECTORS AND TRANSPORT PATHWAYS FOR THE CONTAMINATION SPREAD

During the contamination event, the PHMC Radiological Coordination Team identified a Data Analysis team, consisting of Site radiation protection professionals. Their task was to evaluate the radiological contamination data being collected as a result of the contamination event in and around the affected area and to determine the likely vectors for the spread of contamination and potential sources of contamination. The Data Analysis team was formed to aid in the immediate control and ensuing investigations of the contamination event. The team also was to provide conclusions and recommendations to management for the continuing radiological control programs.

The Data Analysis team's conclusions supplement the causal analysis efforts. The team identified several vectors and pathways that could have resulted in the radioactive contamination found in and around the affected area:

- Human- and work-related events and activities
- Deep-rooted vegetation
- Rodents
- Ants and other burrowing insects
- Flying insects (fruit flies)
- Human vectors and cross contamination where personnel contacted the contamination.

Each of these vectors and pathways has had an effect on the contamination status of the affected area. They are discussed more thoroughly in Appendix B.

The team concluded that fruit flies contacting contamination in the 241-ER-152 Diversion Pit were the primary vector involved in the contamination spread that resulted in identification of contamination outside of controlled areas of the Site and offsite in the landfill.

D3.4 PICK-UP AND DELIVERY OF REFUSE TO THE CITY LANDFILL

The dumpster at the MO-967 Mobile Office was emptied at approximately 7:45 a.m., September 28, 1998. Refuse inside the MO-967 Mobile Office was discovered to be contaminated at approximately 8:45 a.m. that day. This resulted in more surveys, including one performed at 11:30 a.m., of the nearly empty dumpster outside the MO-967 Mobile Office, which also was found to be contaminated. The garbage truck containing the contents of the dumpster from the 7:45 pick-up dumped its load at the City landfill at approximately 1:30 p.m. If the group that manages the refuse pickup service (Transportation Operations) had been promptly notified that the contents of the dumpster might be contaminated, the material might not have been dumped at the City landfill. Two additional loads of contaminated waste were dumped at the City landfill before Transportation Operations finally was notified at a meeting on September 30. At that time, refuse dumping ceased.

D3.5 USE OF AN OFFSITE LANDFILL

A potential for inadvertent transfer of radiological contamination to an offsite landfill had been recognized at the Hanford Site for some time. To address that issue, early in fiscal year 1992 the Site developed Project L-063, Solid Waste Transfer Station, to build an onsite transfer station where refuse could be surveyed before release for offsite disposal. However, the project was not funded and was canceled in January 1992. In October 1995, the U.S. Department of Energy, Richland Operations Office (RL) entered into a contract with the City of Richland to use the City landfill for disposal of nonradioactive, nonhazardous solid refuse. The Hanford Central Landfill was closed down on March 31, 1996.

The City of Richland Landfill Contract, Section B-2, states:

> *"The City of Richland will construct a facility to review wastes received under this contract. This facility will be amortized by all revenues received by all users of the facility during the life of this contract. If revenues received by all wastes using this facility during any federal fiscal year are less than $432,900 DOE shall pay the city the difference between the actual amount received and $432,900. This payment shall be made in the first quarter of the federal fiscal year after billing to DOE by the City of Richland."*

D4.0 ROOT CAUSE

ROOT CAUSE:

Inadequate processes to prevent contamination via biological vectors (fruit flies) from spreading contamination outside of radiological areas (contamination areas).

JUDGMENT OF NEED:

Strengthen the implementation of existing administrative and engineering radiological controls, and establish new programs and processes to identify all potential vectors (including biological) and prevent the spread of contamination.

D5.0 DIRECT CAUSE

DIRECT CAUSE:

Flying insects (fruit flies) spread contamination from the 241-ER-152 Diversion Pit to controlled and uncontrolled areas in or near the 200 East Area.

JUDGMENT OF NEED:

Prevent accessible conditions (e.g., open containment) to contaminated work locations and attractant conditions (e.g., moisture, nutrients) for flying insects.

D6.0 CONTRIBUTING CAUSES (CC-#)

CC-1 The contamination fixative used on the 241-ER-152 Diversion Pit is suspected of attracting fruit flies.	
Investigation Findings:	*Judgments of Need*:
• *The fixative has not been evaluated to see if it is an animal attractant.* • *No system is in place to ensure that fixative issued from the stockroom is not used beyond the manufacturer's expiration date and that secondary containers are controlled.* • *No assessment has been performed to determine appropriate conditions for storing fixative after it is issued from the stockroom.* • *Formal processes have not been established for cleaning containers, including sprayers, before introducing fixative from a new batch*	• *The use of glycerin/monosaccharide-based fixatives should be stopped until it can be demonstrated that they are not an animal attractant.* • *All fixatives, including those currently used at the Hanford Site, should be studied to determine if they have the potential to act as an animal attractant.* • *A system should be established to ensure that fixative is not used beyond the manufacturer's expiration date and that secondary containers are controlled.* • *Temperature effects should be studied before fixatives are allowed to be stored at elevated temperatures.* • *Fixative processes should be modified to include provisions for containers, including sprayers, to be emptied and cleaned following each application.* • *Containers of fixatives in the field should be stored consistent with their contents.*

CC-2 No procedure exists to interdict refuse service when contamination is detected.	
<u>Investigation Findings</u>: *The group that manages the refuse pickup service was not promptly notified that the contents of dumpsters might be contaminated. If the garbage truck drivers had been promptly notified, the volume of potentially contaminated waste dumped at the City landfill would have been significantly reduced or might have been eliminated.* *No requirement is in place for surveying refuse before it is picked up. An intermittent survey of dumpsters is conducted.*	<u>Judgments of Need</u>: • *Establish a system to notify Transportation Operations of any suspect contamination that inadvertently may have been picked up.* • *Establish a method for controlling or determining the contamination level of refuse in dumpsters before the refuse is moved off site.*

CC-3 No policy is in place establishing routine surveys of areas with past known contamination spreads caused by biological transport vectors.	
<u>Investigation Findings</u>: *The August 4, 1998, discovery of a contamination spread via a biological transport vector (rodents) at the B Plant K-3 Filter Pit Encapsulation Facility resulted in an alert to surrounding facilities to increase their radiological surveillances. This communication was informal.*	<u>Judgments of Need</u>: E*stablish a policy requiring routine surveys of areas with past known contamination spreads caused by biological transport vectors.*

CC-4 The current policy of protecting contaminated facilities from biological intrusion does not provide for a proactive review of potential intrusion points with preventive corrective actions.	
<u>Investigation Findings</u>: *Potential sources of intrusion are not readily apparent until a contamination event has occurred. The detection of intrusion opportunities is not currently part of required surveillances of contaminated systems.*	<u>Judgments of Need</u>: Incorporate r*outine surveillances of contaminated facilities and systems with biological intrusion potential into facility operations and maintenance.*

CC-5 The Project Hanford Management Contract (PHMC) team has not adequately integrated Sitewide biological control.	
Probable Cause: *The change from a Management and Operating contract to the current PHMC resulted in a fractured organization. DynCorp Tri-Cities Services, Inc., has been tasked with resolving this issue. This new program is in its infancy and was not established at the time of the fall 1998 contamination.*	*Judgments of Need*: • *Biological control should be integrated. A review of Sitewide services should be performed to determine if needs could be met better by integrating all biological control efforts among contractors.* • *The roles and responsibilities of biological control at the Hanford Site need to be clarified.*

CC-6 No policy is in place to prevent animal encroachment at refuse collection points.	
Investigation Findings: Animals in search of food are attracted to dumpsters, gaining access through openings. This is especially true of mice entering through bung openings on the bottom of dumpsters that allow for water drainage.	*Judgment of Need*: *Establish requirements to keep dumpsters closed when not in use and to install access guards or screens on the bottom drainage openings.*

CC-7 No policy is in place to minimize food substances from being located near known contamination areas.	
Investigation Findings: *Mice, flying insects, and other animals are attracted to food.*	*Judgment of Need*: *Evaluate the need for requirements to control food substances, including refuse, from entering areas near known sites with contamination spread potential.*